Bull. Inst. Zool., Academia Sinica **1**: 17-24 (1962)

OBSERVATIONS ON THE BIOLOGY OF THE CARNIVOROUS SNAIL *EUGLANDINA ROSEA* FERUSSAC[1]

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Received for publication March 13, 1962

The giant African snail, *Achatina fulica* Bowd. (Achatinidae), has been a widely distributed crop pest in Asia and many Pacific islands (1, 2). This snail spread rapidly throughout Taiwan after its introduction in 1932, and caused great damage to the living crop plants. It appeared to resist various control measures, and it seems probable that the situation might become worse if left unchecked.

Euglandina rosea (Feru.) is a native snail of Florida and Southeastern United States. Muma first observed it feeding rather voraciously upon a newly hatched beneficial snail *Drymaeus dormani* (Biney) in the citrus groves of Florida (3, 4). Krauss collected a number of live *Euglandina rosea* and sent them to Oahu, Hawaii for testing and releasing. After two years of testing, it was proved to be the most promising predator of the giant African snail (2). This was confirmed recently by Davis, who reported further on its slug-predation abilities (5).

In October 1959, the Institute of Zoology, Academia Sinica started a program to study the possibility of controlling the snail pests here by means of *Euglandina rosea*. The biological behavior of this snail was carefully studied to explore its capacity of adaptation to the local environments, and the data obtained is presented in this paper.

MATERIALS AND METHODS

Euglandina Rosea

50 snails were obtained from the Division of Entomology and Marketing, Board of Commissioners of Agriculture and Forestry, Hawaii in October, 1959.

Insectary Rearing

Each group of the newly deposited eggs was carefully placed in a petri dish cushioned with moistened tissue paper to keep them from drying (Fig. 3). Young snails were reared in a screened wooden breeding cage (Fig. 4) with a depth of 5 to 8 cm screened, sandy soil on the floor. Each cage contained only the snails which were hatched from the same group of eggs, and was supplied with newly hatched host snails no larger than the predatory snails. For the host snails green vegetables such as cabbage, lettuce or cucumber, and a little calcium were supplied. Mature predatory snails were also reared in a similar manner but fed instead with larger host snails about 2.0 cm in shell length. Water was supplied once a day to keep the cage moist.

Field Rearing

The Eggs and the newly hatched snails of one month old were reared in the insectary, then removed to the field-screened breeding cage which was about 175 × 135 × 135 cm in size (Fig. 5).

EXPERIMENTAL

Egg

The egg was white, oblong in shape, surface granulate, about 6-7 × 4-5 mm in size (Fig. 6). The date of incubation period and percentage of egg-hatching in different months are shown in Table I.

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[1] This study was done in the insectary of the Department of Applied Zoology, Taiwan Agricultural Research Institute, aided financially by the Institute of Zoology, Academia Sinica.

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TABLE I

Relationship between incubation period and percentage of egg-hatching of Euglandina rosea (1960)

Date of oviposition	Date of Hatching	No. of eggs laid	Egg-hatching rate		Incubation period, days	Average temperature during incubation, F		
			No.	%		Max.	Min.	Mean
June 23-24	July 27-30	18	16	88.79	33	91	80	85.5
June 27	July 25-30	15	14	93.33	37	91	80	85.5
July 13-17	Aug. 16-19	21	21	100.00	33	88	79	83.5
July 18-19	Aug. 16-20	20	20	100.00	28	87	79	83
Aug. 14-15	Sept. 11-16	23	22	95.65	27	86	78	82
Aug. 30-31	Sept. 28-30	26	24	92.31	28	86	78	82
Sept. 17-18	Oct. 22-25	31	28	90.32	34	82	75	78.5
Sept. 26	Nov. 2-5	12	12	100.00	36	79	73	76
Oct. 1-2	Nov. 6-18	21	21	100.00	36	77	71	74
Oct. 9-10	Nov. 22-Dec. 1	11	10	90.90	43	74	67	70.5

Young snail

The newly hatched snail was oblong in shape, and testaceous; its shell was smooth with a polished surface, whorls 4, about 5-6 mm in shell length (Fig. 7). The color of the shell gradually became darker, and the number of whorls increased to 7 when it matured. Young snails seemed more active and ate as much as, or even more than the mature ones. The length of premature period was season-dependent: those snails which were hatched close to winter took a longer time to mature, because of hibernation (Table II).

TABLE II

Length of immature period in various growing seasons

Date of hatching	Date of first mating	Length of immature period, days
*March 6, 1960	June 24, 1960	110
June 9, 1960	March 18, 1961	282(over winter)
August 21, 1960	May 4, 1961	256 (〃 〃)
Sept. 1, 1960	July 15, 1961	317 (〃 〃)
Oct. 28, 1960	June 21, 1961	236 (〃 〃)
Nov. 19, 1960	July 21, 1960	244 (〃 〃)

* The egg was produced by the snail which was reared at the room temperature around 75-85 F during the winter time.

Adult

Characters

Shell is spindle-shaped, about 3-6 cm in length and 2 cm in diameter; dextral, whorls 7, suture deep, pink color, surface polished, with distinct, regular and longitudinal lines of growth; body dark grey to black, ventral side whitish (Fig. 8).

Beginning of Spring Activity

Although the snails remained motionless during the winter months, they could maintain normal activity at controlled temperature between 75-85 F with sufficient humidity. Under natural climatic conditions, spring activity occurred in early March when the temperature was favorable. Generally speaking, normal feeding resumed in April, mating and ovipositing started in May or June.

Copulation

Being hermaphroditic, *Euglandina rosea* produced eggs after mating. A few snails started mating in late March or early April, but the majority began in May. It usually took place late at night or in the morning. The total time for the whole process varied from 1 to 4 hours, very rarely more than 5 hours. One snail might mate 1 to 4 times before the eggs were produced.

Oviposition

About 1 to 3 weeks after mating, *Euglandina rosea* laid its eggs in a shallow pocket in the soil. The upper ones can normally be seen without removing the soil (Fig. 9). The oviposition always began before daybreak. The half-grown and the aging ones produced fewer eggs, and an average of about 25–35 eggs were produced by one snail at one oviposition. It took 1 to 4 days to complete one oviposition. Usually, the interval between two successive ovipositions was 2 to 4 weeks, but it was 6 to 7 months in the over-wintered snails.

Records were kept on 10 snails to determine the number of eggs laid under indoor conditions. The results obtained are given in detail in Table III.

TABLE III

Eggs laid by Euglandina rosea under indoor temperature conditions (July 1960–October 1961)

Snail number	Average No. of eggs per month	No. of ovipositions	Total No. of eggs
Ⅲ/5	34.5	8	103
Ⅲ/7	17.0	6	104
Ⅲ/9	17.3	11	107
Ⅴ/1	21.4	8	83
Ⅴ/2	13.8	9	163
Ⅶ/1	32.6	8	162
Ⅶ/8	17.0	6	102
Ⅵ/1	50.5	4	101
Ⅵ/2	20.8	5	83
Ⅵ/10	15.6	6	78

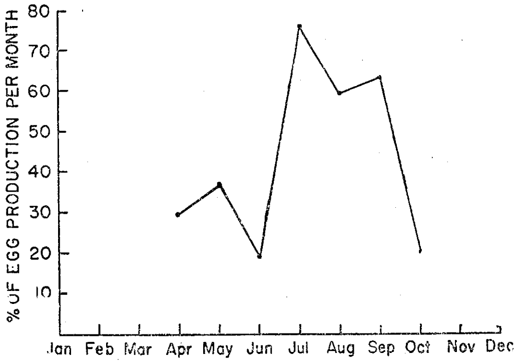

Fig. 1. Percentage of egg production for calender months (1960–1961).

To determine the monthly variation of egg production, a group of 54 snails was studied. The data given in Fig. 1 shows that eggs were produced from April to October.

Longevity

Longevity of adults was determined at room temperature. 30 snails were observed from the first mating until death. Its range was found to be 2–16 months, with an average of 13 months.

Starvation and Cannibalism

Like other kinds of land snails, *Euglandina rosea* was able to withstand complete lack of food for a long time. Previous observation showed that two-month old snails could stand complete starvation for 3 months (6). In this study, it was found that 91–97% of newly hatched snails survived for 2 months without food or water. Cannibalism very rarely occurred in the presence of the host snails. Although it was found occasionally among the newly hatched snails, it was not normally seen even during a long period of starvation.

Life Cycle

The life cycle of *Euglandina rosea* may be divided into three stages: the egg, young snail and adult. In general, the egg stage lasted about 30 to 40 days, the young snail stage about 4 to 10 months depending upon whether over-wintering was encountered, and the adult about 2 to 16 months. The entire life lasted 14 to 24 months. Under the conditions of field rearing, snails hatched in June began producing eggs in October, hibernated from January through April, and produced eggs again in May. In laboratory rearing, however, some snails hatched in August, hibernated from January to April, oviposited from May through October, and died mostly in October shortly after their last oviposition.

Hibernation and Estivation

Euglandina rosea usually hibernated from December to March, sometimes until early April. Most of the snails were found to hibernate under the leaves on the ground, or beneath pieces of brick or stones or in any other shaded places. It retreated within the shell and secreted a membranous, silver-like film over the open end. Sometimes they resumed moving around when the temperature was raised over 63 F or after a heavy rain or rain shower. Estivation occurred as a result of dryness of the environment and food shortage. Whenever the environmental conditions improved the snails recovered quickly.

Food Range and Predation

Euglandina rosea fed on the giant African snail and other phytophagous snails, *e. g.*, *Bradybaena similaris* Ferus. (citrus pest, 6, 7), *Opeas pyrgula* Schmacker et Bottger (vegetable pest), *Opeas gracile* Hotton (sugar cane pest), *Limax* sp. (pineapple flower pest) and *Philomycus bilineatus* Benson (strawberry pest, 7).

Euglandina rosea usually started its searching activity (Fig. 10) a little while before attacking the host snails (Fig. 11). This snail always preferred the smaller sized host snails if given a choice, sometimes eating the complete content together with the shell. The size of the host snail killed by *Euglandina rosea* varied from newly hatched ones up to those 2.5 cm in diameter of the snail. A mature *Euglandina* snail was able to attack host snails twice its size. It was much more active and swifter in locomotion than the latter.

To determine the predatory activity during the daytime and night, two cages with 13 snails each were observed from May to September, 1961. Host snails were replenished from time to time and the empty shells, as the evidence of complete predation, were collected and recorded twice a day. Table IV shows that *Euglandina rosea* is more active in predation by night.

As to the predatory ability, an observation was made on 27 snails hatched on March 6, 1960. The average number of the giant African snails killed by one Euglandina snail per month is shown in Fig. 2.

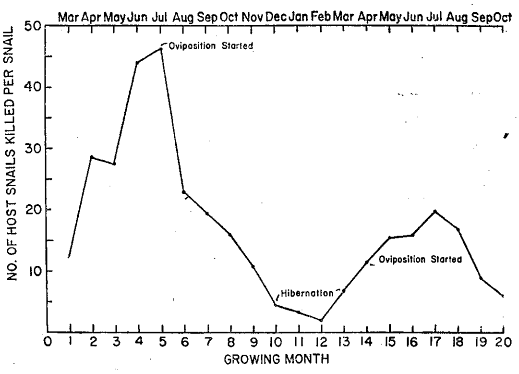

Fig. 2. Average number of the giant African snails killed by *Euglandina rosea* per month (March 1960-October 1961).

DISCUSSION

The purpose of this project was to rear *Euglandina rosea* under both insectary and field conditions, and to determine its adaptability to the climatic conditions in Taiwan. The data obtained would serve a basis for evaluating its ability to control the local giant African snail, the eradication of which has been the deep concern of interested workers. Experiences obtained during the past two and half years, pending large-scale field trial, indicate that the outlook is encouraging.

On April 20, 1960 we released intentionally 18 *Euglandina rosea* snails in a vegetable farm near the Department of Zoology, Taiwan Agricultural Research Institute. They were one month old, reared in the insectary, about 1 cm in shell length. Three months later, we recovered a full-grown specimen on the veranda of the Department, with 4.25 cm shell length. It was about

TABLE IV

Daily predatory activity of Euglandina rosea

Cage / Month	F_1/VI					F_2/III				
	No. *Eugland-ina*	Day		Night		No. *Eugland-ina*	Day		Night	
		No. hosts killed	% hosts killed	No. hosts killed	% hosts killed		No. hosts killed	% hosts killed	No. hosts killed	% hosts killed
May	13	28	10.37	242	89.63	13	107	36.03	190	63.97
June	13	71	30.08	165	69·92	12	173	34.33	331	65.67
July	12	57	19.26	239	80.74	11	167	27.97	430	72.03
August	11	28	18.18	126	81.82	11	86	27.65	225	72.35
September	11	17	12.98	114	87.02	7	35	25.74	101	74.26

twice as long as the brood reared in the insectary, and was much more active with a well-grown appearance.

On February 5, 1962, 22 marked *Euglandina rosea* snails, being reared in a field screen cage, escaped by accident. From March 5 to May 5 the same year, we were able to recover 15 of these snails around the surroundings. All these snails were very active and swift in motion.

On March 15, 1962, we recovered 3 snails which were released, right after hatching, in a place near our insectary in the summer of 1960. Their respective lengths of 5.45, 5.33, and 5.10 cm came close to that of their longest ancestor (5.7cm) from Hawaii.

Euglandina rosea were also reared in Pingtung and Chiayi. They all showed much better development than those reared in the Taipei insectary.

From the facts mentioned above, we believe that this species will establish itself easily on this Island if it is liberated in the field. The available data highly favor its use as a means for controlling the giant African snail in Taiwan.

SUMMARY

50 *Euglandina rosea* Ferus. were introduced from Hawaii and reared under natural climatic conditions in insectary and in field (Taipei). Their biological behaviors were studied to serve basis for evaluating their potentialities of controlling the giant African snails, which caused a great damage to the local farm products. The following results were obtained:

1) *Life cycle.* Egg stage 30-40 days, immature stage 5-11 months, adult stage 2-16 months; the whole life cycle lasted about 24 months. Average total number of eggs produced by one snail: about 100. Egg-hatching rate: 85-100%.

2) *Biological activities.* Mating, oviposition and predation usually occurred at night. Mated 1-4 times before each oviposition. Average number of giant African snails killed in the life cycle of a single *Euglandina rosea:* 300-350. Phytophagous snail range of predation: *Achatina fulica* Bowd., *Bradybaena similaris* Feru., *Opeas pyrgule* Schm., *Limax* sp. and *Philomycus bilineatus* Benson. Cannibalism was rare in the presence of the host snails, being occasionally found among the newly hatched snails. Stood starvation for 2-3 months.

3) *Hibernation and estivation.* Hibernated from December to March, and estivated in case of dryness and food shortage.

4) *Euglandina rosea* reared in the field developed quicker, and were robuster than those reared in the insectary. Adaptability to the local environments appears to be encouraging.

Acknowledgements We are indebted to Dr. H. M. Liang, Director of this Institute for his constant encouragement in this study; to Mr. Alvan Thistle, Director of the Division of Entomology and Marketing, State of Hawaii, Board of Commissioners of Agriculture and Forestry for giving the information on rearing techiques; to Miss Mabel Chong, State Department of Agriculture and Conservation, Hawaii, for her constant help in supplying information concerning our study. Special thanks are also due Dr. Suny-yang Lee, Senior Entomologist of the the Department of Applied Zoology, Taiwan Agricultural Research Institute, for his help in photographic illustrations.

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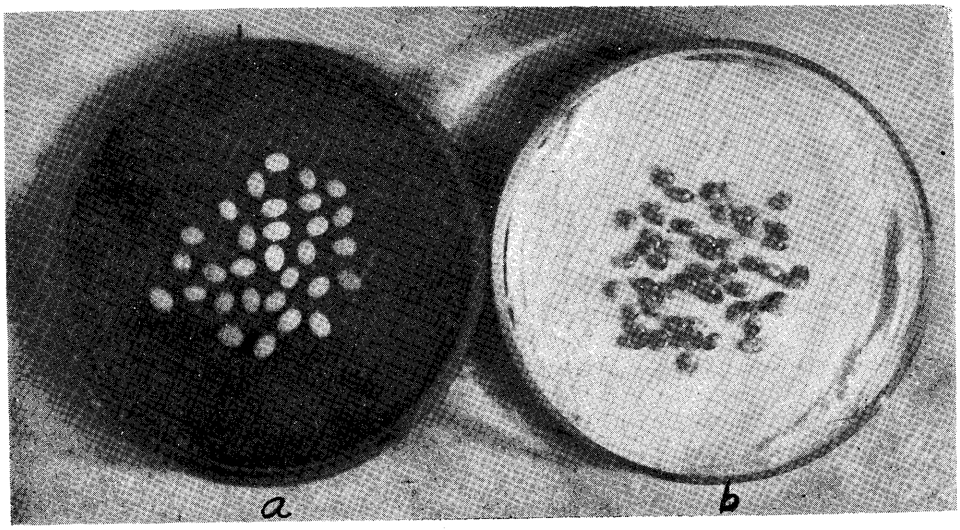

Fig. 3. Eggs rearing: a. eggs, b. eggs and newly hatched snails.

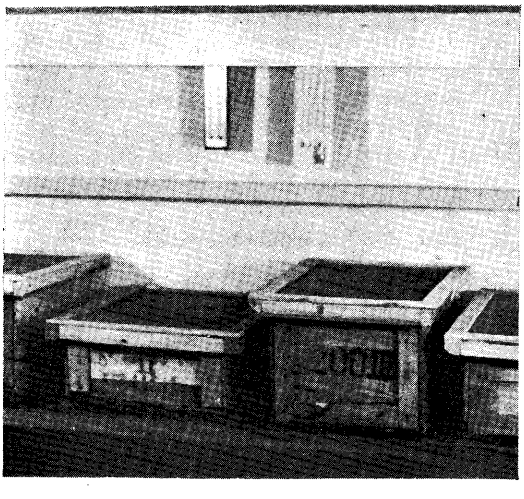

Fig. 4. Insectary breeding cages.

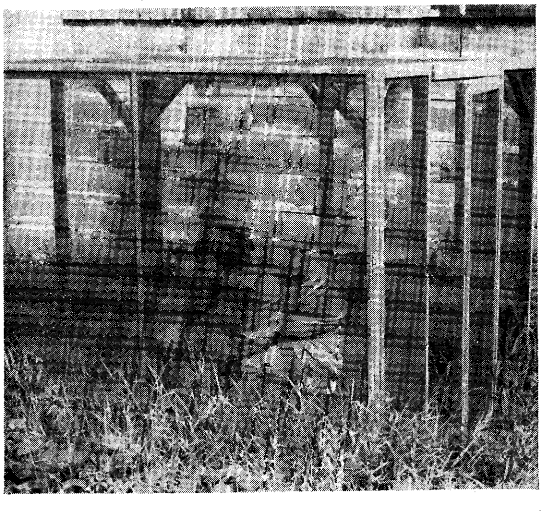

Fig. 5. Field breeding cage.

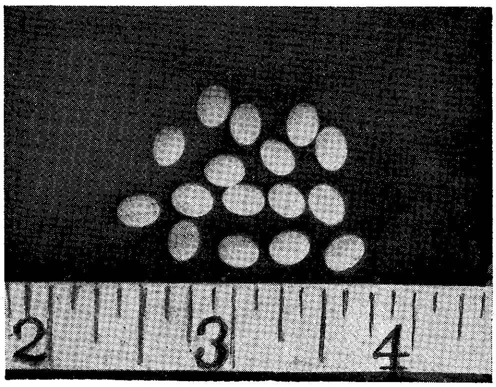

Fig. 6. Eggs, *Euglandina rosea.*

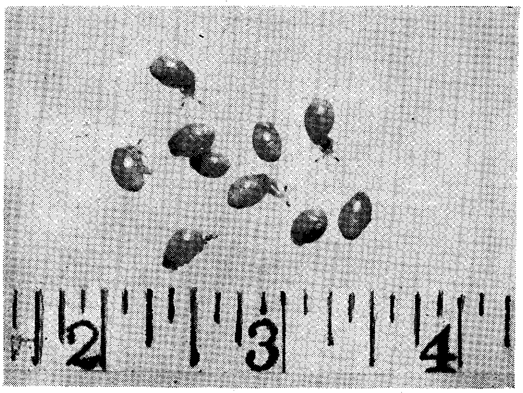

Fig. 7. Young snail, *Euglandina rosea.*

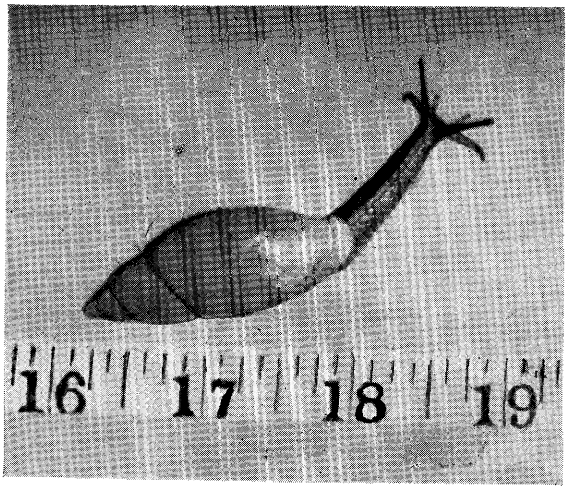

Fig. 8. Adult, *Euglandina rosea.*

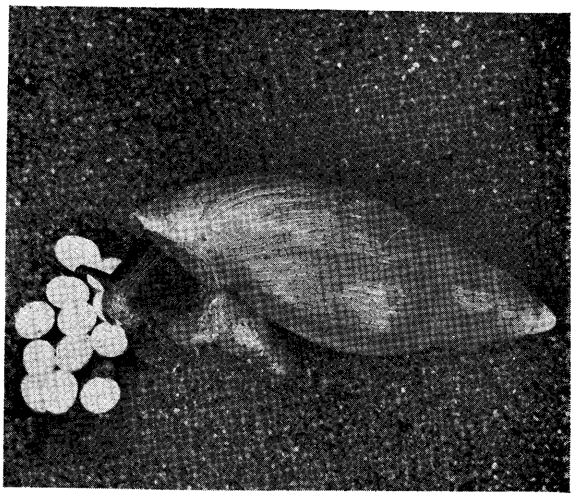

Fig. 9. Mature snail and its deposited eggs.

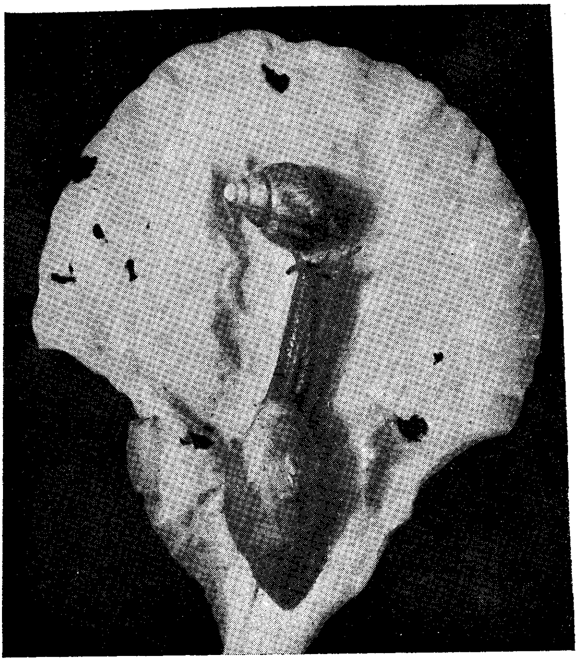

Fig. 10. *Euglandina* snail searched for host snail.

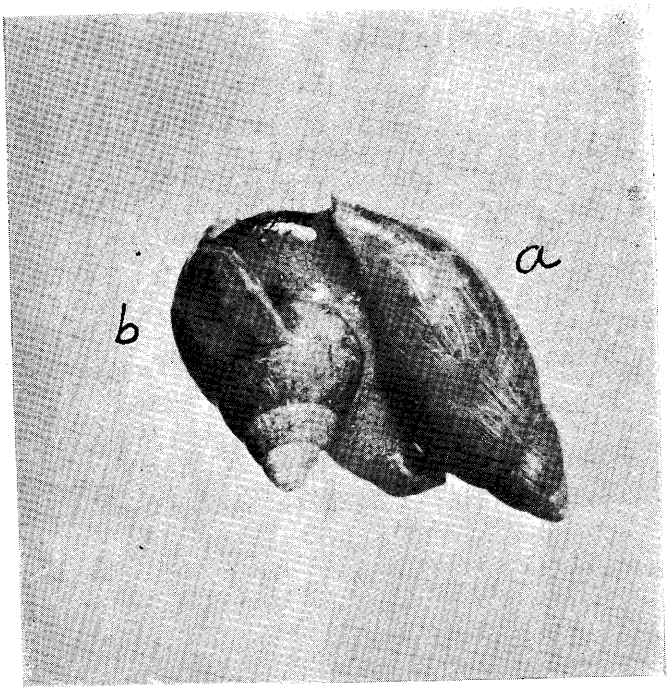

Fig. 11. *Euglandina* snail fed on the giant African snail. a. *Euglandina snail* b. Giant African snail.